Technical correspondence

More on Pierce

Dr. Pierce's article on "Men, Machines, and Languages" (July, pp. 44–49) seems to make many cogent points about computers, men, and language. However, one point he mentions has too many barbs on it to allow one to pass over it quickly or painlessly.

He mentions briefly some of his views on artificial intelligence with a bravura that intimidated me for a long time. As I see it, Dr. Pierce's only comment on the artificial intelligence field's seeming lack of useful (read pragmatic) output is "so what?". The whole tone of his discussion makes me feel that he looks at artificial intelligence as a type of foppery second only to a Ph.D. degree in underwater basket weaving. His tone further suggests that even though many people are "wasting" their time on artificial intelligence for machines, one should not worry about this foolishness since computers have many more useful tasks that far outweigh the "trivia" of artificial intelligence research.

The point that bothers me is that earlier in his article, Dr. Pierce states that, "Computers are worthy of study because they do useful things for man, and because man wants to make better computers that will do even more useful things." If Dr. Pierce's sentiments about artificial intelligence are universal, then who is supporting the artificial intelligence research being done today? Surely many companies cannot afford the luxury of "nonuseful" research. Then who? The government? I hardly think that many government grants will tolerate useless research over a period of years by many different people working on the same problem. It is a fact that many companies do support artificial intelligence research because they "think" some results may be "useful," which is good enough for them. Thus, Dr. Pierce's comments do not seem to speak for everyone even though they do give that impression.

It seems that a practical and useful world would be the best world possible regardless of the seeming uselessness of art, music, literature, and other such trivia. Pattern recognition may be a basis for human perception, yet to study humans and machines in pattern grokking* situations is useless—I think not. Finally, if one cares to, one can read the following argument into Dr. Pierce's article:

> If one uses a screwdriver for a purpose other than that of driving screws, play along with him even though it is rather foolish to "misuse" the screwdriver in this manner.

My comment is that if I don't have a tool specifically designed for the job in hand, but a screwdriver will work, then I'll use the screwdriver, and don't tell me how foolish it is to do so until you can give me that better tool. In fine, when Dr. Pierce said that he did not intend to say much about artificial intelligence, he made a mistake. He should not have said anything.

Richard P. Karasik
McGill University
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I would like to comment on Dr. Pierce's recent article in IEEE SPECTRUM. Dr. Pierce is such a fine communicator himself that he is very apt to snarl the inattentive reader into believing that the computer will never be able to be instructed by natural languages. But as delightful as his article is, I find some key flaws in his argument.

I would restate his premises in reverse order:

1. Computers cannot be programmed in natural language except that computers understand meanings—because
2. Natural language syntax is dependent upon semantic meaning and subordinate to it—and because
3. Programming syntax is essential to computer operation.

I would like to examine each of these statements in turn, beginning with no. 3. However, I would not attempt to take issue with statement 3 since sequence and format are admittedly important to computer programming although I would not feel comfortable making such a statement myself.

Statement 2 is much more vulnerable. Dr. Pierce may know an engineering dean who speaks understandably in nonsentences but I would also call your attention to other examples of information transferred outside of normal language use. For example, Red Skelton, the comic pantomimist, can communicate without language—without syntax or semantics—but I am confident that the sequence of his gestures is extremely important to the transfer of his message. I don't think it is quite fair to rationalize, as Dr. Pierce does, that syntax is unimportant in human communication. However, it is true that messages can be conveyed in several nonsyntactical ways such as in making use of prior information transfer—preprogramming if you please—and in the redundant use of symbols.

There is a degree of tradeoff between syntax and redundancy. That is why syntax is important to computer programming. Redundancy is minimal. The same principle holds with natural language. When the message is stripped of redundancy for brevity, its syntax becomes very critical to its clarity. This principle is generally acknowledged also in the field of information retrieval where the syntax of "links" and "roles" has been proposed as a method of achieving a greater precision in document searching, or where the syntax of hierarchical indexing is considered far superior to coordinate indexing. I would, therefore, submit that syntax is indeed important to human communication.

If statement 2 is invalid, statement 1 falls without support. But I would propose a slight modification of statement 1 to make it more acceptable to those diehards Dr. Pierce speaks about. I suggest it read as follows:

"Computer programming in natural language may be realized when algorithms for natural language are realized."

On a theoretical basis there should exist a natural language algorithm. If we strip away all of the gestures, verbal inflections, etc., from a message in English, then, according to Shannon, the information resides in the differences in symbol sequences between the base structure shown in Pierce's example no. 6, the second-order word approximation, and the actual message. The actual message is constrained by the same limiting rules as is the example, but in the case of the message structure, the rules are less constraining. This is simply because Pierce's example represents those statistically frequent sequences found in large quantities of text, and an

* The word "grok" is a Martian term used by Robert Heinlein in his book, *Stranger in a Strange Land*. The term encompasses the English concepts of recognize, understand, and comprehend.

actual message may be influenced less by these statistical tendencies than by the many other structural rules of the English language not represented in the example.

Now assuming that the algorithm for Pierce's example is reversible—and there's no reason why it shouldn't be—we can generate an algorithm from it. Likewise, there should be an algorithm for the message and it also should be reversible. But we should really look for an antialgorithm in the probabilistic sense, since its information content is determined by the uniqueness of symbol sequence rather than consistency. Yet this uniqueness is very subtle. If the message symbol sequence is too far removed from the base structure it will have to be related to structures other than the given example, such as Webster's Dictionary or rigid syntax. But assuming that this antialgorithm is possible, then it should be possible to subtract the noninformation structure as in the example from the message to yield the essence of the information in the message. Since I have not seen a proof that this is impossible, I would submit that this information essence could be in algorithmic form.

Jay Hilary Kelley
Philadelphia, Pa.

Concerning most of the points in Dr. Karasik's letter, I've said my say in "Men, Machines, and Languages." One point I did not touch on. Dr. Karasik says, "I hardly think that many government grants will tolerate useless research over a period of years by many different people working on the same problem." My experience does not lead me to believe this. As James Thurber said, you can fool too many people too much of the time.

Dr. Kelley concedes that we can communicate in spite of imperfect syntax, and I think that in conversation we mostly do. Further, the words of a conversation, hard if not impossible to understand out of context, serve a real purpose in the conversational context of locale and background.

The end of Dr. Kelley's letter presents an argument (not a proof) that it ought to be possible to interact with a computer in natural language once we have "algorithms for natural language." I hope that Dr. Kelley will go right ahead and provide these algorithms, and maybe the philosophers' stone, too.

J. R. Pierce
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Ph.D. shortage in industry

According to the latest manpower forecast, our industrial firms and industrial laboratories will be facing a shortage of people with advanced college educations. This trend is particularly true in the fields of science and engineering because it appears that, for some reason or other, our young high-school graduates have lost interest in these fields. On the other hand, Ph.D. graduates are the ones most likely to discover new products and new utilizable areas for our future industry.

I know from my many decades of experience in the academic field and in industry that our young creative people —and we have lots of them—are able to develop their creativity if they are given the opportunity. Until now, government-sponsored research at universities in the United States was on a very large scale —$2 billion annually. Although this is only about 10 percent of the total amount spent on research and development per year in the U.S., this program nevertheless made it possible in the past for a large number of Ph.D.'s and Sc.D.'s (doctors in some field of science) to do their theses at universities or technological institutes, thereby acquiring the experience for the start of a creative future.

The U.S. government's science policies were formally reviewed at the beginning of this year by a European group of four examiners of the Organization for Economic Cooperation and Development. They came to the same conclusion.

We need no better proof for this conclusion than the fact that the United States won a large number of Nobel Prizes in recent years. Some of these Nobel Prize winners had started entirely new technologies, such as the integrated circuit technology or the laser technology.

This government program of research subsidizing on a gigantic scale has now been cut back substantially with the result that many universities and technological institutes will no longer receive money for the funding of theses or research programs. Consequently, we will lose a large number of young men and women as prospective scientists and creative engineers.

I believe there is one cure for all this. Educational institutions do not have the money to provide funds for research. Industry, on the other hand, has funds and facilities for this purpose. Therefore, the educational institutions should give up their practice of compelling degree candidates to reside and to do their required research on the premises of the educational institutions. If the schools were to give up these requirements, the candidate could, after having collected all his course credits, join the industrial organization of his liking. There he could eventually work on a thesis topic, which would be one of practical value to that particular company and at the same time would be acceptable to the candidate's academic thesis advisor. It should be noted here that there are government and industrial research reports of such high caliber that they equal an accepted doctoral thesis in spite of the fact that the writers do not have Ph.D. degrees.

We have many working people without doctor's degrees, who have already fulfilled the most essential criterion for this degree. These persons have proved their ability to do creative research in their fields of endeavor without a doctorate. They have pushed the frontier of science and engineering ahead. Isn't this the reason for giving a doctor's degree? Isn't it to acknowledge that the individual to whom the doctor's degree was granted had by virtue of his or her thesis made a contribution to the advancement of the field of science or engineering? But the people who have no doctoral degrees do not receive the credit in their professional advancement they would doubtless get if they had this degree.

There are technological universities in the eastern part of the United States who have introduced long ago the practice suggested here. But their number is relatively small. The high-level educational institutions situated on the West Coast rarely, if at all, follow this practice.

There are, of course, many understandable objections by university faculties. I had a heated argument on this subject some years ago with a world-famous Nobel Prize winner. What the universities want, of course, is to plant the candidate for a year or two into a real scientific, creative, academic atmosphere, which very few industrial research laboratories actually have.

I once wrote, "With a few, but very commendable exceptions, most of these excellent men work under ever-increasing pressure, which is built up by the front office where most of the people just want results and are completely unaware of the fact that orchids do not grow in every back yard, for they need the appropriate climate."[1]

In other words, the universities' point of view is justifiable, but until the "Golden Days of Aranjuez" come back

again and the government will be able to support university research, I think my suggestion would be the easiest way of solving our future creative manpower shortage.

The thesis advisor would pay periodic visits to the industrial laboratories where the thesis work would be progressing to supervise the research. This research would certainly be beneficial to him in that he would have frequent access to an industrial climate new and otherwise closed to him. At the same time he would be able to get acquainted with the scientists and engineers working in industry in his area of interest. Such meetings would, I believe, be advantageous to all concerned.

I do not think that the universities can reasonably expect help from industry in general in any other way than the one proposed. The future prosperity depends on new discoveries and on new products. We will not have this prosperity without properly schooled and trained individuals who have the inborn capability to achieve this goal.

If university administrations were to adopt the suggested new attitude for a transitory period, and if they were to start this at the beginning of the coming academic year, it would be very wise and very welcome.

Victor A. Babits
Palos Verdes Peninsula, Calif.

1. Babits, V. A., "Science and engineering education: Europe—U.S.A.," *IRE Trans. Education*, vol. E-1, pp. 110–116, Dec. 1958.

Another Moore supporter

I congratulate Prof. A. D. Moore on his excellent article, "The Modern Engineering Bandwagon," in the July issue of the IEEE SPECTRUM (pp. 79–82). Some of the changes that have taken place in engineering education may be regarded as a direct consequence of the attitude of our academic community. Since the emphasis on publishing papers in respectable journals is increasing, this defines by implication a goal to be achieved. There is no doubt that, in order to publish a paper, one has to achieve a certain level of excellence in his work. A somewhat premature rush to publish has, however, been responsible in a way for the bandwagon. This phenomenon is natural in that it conforms to the minimal principles and optimality for achieving the desired goal.

Second, the rate at which information is being generated has been growing rapidly. At the same time, availability of information has been facilitated greatly. This is perhaps the main reason for our retaining (in our brain) the "address" of the information rather than the complete information itself. Let me explain this in a little more detail. Several distinct areas of specialization have developed within the field of electrical engineering. A student, therefore, cannot be expected to learn and retain even the basic information regarding all facets unless such information is regenerated (reinforced) at frequent intervals. In practice this may result in retaining sufficient details in one's own area of specialization and learning to have quick access to references and sources of information so that other details are retrieved whenever needed.

This point also brings us to another important question. We have entered a stage where the need for rapid exchange of information among several diverse fields is becoming more and more important. For example, study of human system characteristics is having significant influence on the design of physical systems.

Disciplines such as medical electronics, engineering in medicine and biology, and man–machine systems are already receiving more attention in engineering teaching as well as research. How do we, therefore, define the ground level knowledge and capability to encompass such interdisciplinary activities?

I think Prof. Moore's suggestion for introducing, in our educational system, an environment for practical engineering knowledge and skills should receive due attention. There should be more emphasis on practical and real-world problems rather than on mathematical sophistication.

If there is a need for improving engineering teaching, we will have to introduce some incentives for achieving this goal. At the same time we may have to develop criteria for measuring the excellence achieved in teaching.

S. Imtiaz Ahmed
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A footnote to history

As a footnote to Professor Süsskind's interesting article (August, pp. 90–98) on the early history of electromagnetics, I would like to mention still another early experiment. This experiment was performed by Wilhelm von Bezold, a professor of physics in Munich, and reported in German and British scientific journals in 1870. Von Bezold used an induction coil and spark-gap discharge apparatus to establish waves of the order of 15 meters in length on laboratory transmission lines. He obtained experimental evidence of standing waves on the lines by means of Lichtenberg dust figures that indicated the polarity and relative intensity of the electric field.[1,2] Hertz apparently did not learn of the experiment until 1887, when it was mentioned to him by von Bezold at a meeting in Karlsruhe.[3] When he read the original von Bezold paper, Hertz was so impressed by it that he included much of it, along with some interpretive comments, as the third chapter of his book *Electric Waves*. He also expressed surprise that "results so important and so definitely stated should have exercised no greater influence upon the progress of science." Hertz suggested that the fact that von Bezold's contribution had been described as "a preliminary one" might have been responsible for the neglect.[4] It seems more likely, however, that the differences between the alternative hypotheses had not been sufficiently formulated in 1870 to make von Bezold's experiment seem "crucial" in the sense that the Hertz experiments seemed to be in 1888. The famous teacher of Hertz, Hermann von Helmholtz, provided much of the formulation as well as the direct stimulus for Hertz to undertake the experimental investigation.[5]

A question might also be raised as to whether the existence of interference patterns on transmission lines, such as those observed by von Bezold and later by Oliver Lodge, would have constituted an adequate experimental confirmation of the Maxwell hypothesis.[6] Fitzgerald, in his well-publicized address to Section A of the British Association in 1888, argued that the propagation of waves on transmission lines did not constitute an *experimentum crucis* but could be explained by an action-at-a-distance hypothesis.[7] However, Oliver Heaviside, who was perhaps more conversant with Maxwell's hypothesis than anyone else alive at the time, expressed the view that there was little distinction between the interpretation of waves guided by conductors or propagating through air. He argued, therefore, that the experiments with waves along conductors performed by Lodge were "equally conclusive to those of Hertz."[8] It is also interesting that Heaviside, despite the fact that he did not personally be-

lieve in action at a distance even for gravitational effects, did not rule out the possibility that the propagation of electromagnetic waves through a non-conducting space could be explained by "action at a distance, pure and simple." He stated the assumptions that would be necessary for anyone who might wish to continue to support the action-at-a-distance hypothesis.[9]

James E. Brittain
Case Western Reserve University
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1. Hertz, Heinrich, *Electric Waves*, trans. by D. E. Jones. London: 1893; reprinted New York: Dover, 1962, pp. 54–62.
2. Simpson, T. K., "Maxwell and the direct experimental test of his electromagnetic theory," *Isis*, vol. 57, pp. 419–420.
3. Hertz, *Electric Waves*, p. 2.
4. Hertz, *Electric Waves*, p. 3.
5. Simpson, T. K., "Maxwell and the direct experimental test of his electromagnetic theory," *Isis*, vol. 57, pp. 427–430.
6. Süsskind, Charles, "Observations of electromagnetic-wave radiation before Hertz," *Isis*, vol. 55, p. 32, 1964.
7. *The Electrician*, vol. 21, p. 569, 1888.
8. *The Electrician*, vol. 21, pp. 772–773, 1888.
9. *The Electrician*, vol. 21, p. 773, 1888.

Von Benzold's contribution remained unmentioned in the first installment of Charles Süsskind's series on the early history of electronics because he planned to mention it in connection with Hertz's work in the second installment, which appears on pages 57–60 of this issue.

Editor

A misplaced tunnel

Mr. Friedlander's excellent article on the history of railroad electrification in the U.S. (July, pp. 50–65) is a fine start on what promises to be a most interesting series.

One small correction, however: the St. Clair tunnel is under the St. Clair River, not the Detroit, and joins Sarnia, Ont., and Port Huron, Mich. The Canadian National, of which the Grand Trunk is now a part, has always used ferries for its Detroit River crossing.

The Michigan Central (now Penn Central) tunnel under the Detroit River was electrified from the start, using a 600-volt dc third-rail system. The electrification was abandoned about five years ago.

Trains magazine, in September and October 1964, had a good series describing both of these tunnels, including the motive power used.

H. W. Verseput
Rockland, Ill.

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